Advanced Deep Space System Development Program

FIRST DELIVERY PROJECT

David Woerner

NASA/Jet Propulsion Laboratory

david.f.woerner@jpl.nasa.gov

Pasadena, CA

Sep 15, 1997

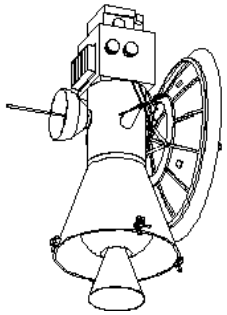
First Delivery Performance

First Delivery Performance Relative to Mars Pathfinder

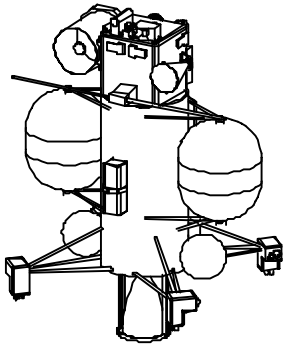
• Comm capability	1000 x improvement
• Computer perf	10-20 x improvement
• Avionics mass	2 x decrease
• Avionics vol	4 x decrease
• Digital elect pwr	10 x decrease
• Analog elect pwr	2 x decrease

Core Spacecraft for Next Wave

X2000

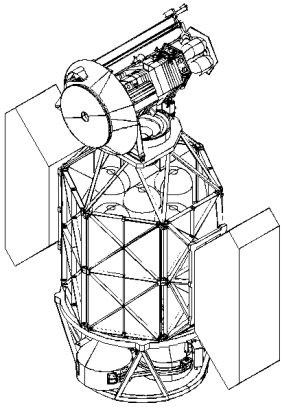


Pluto/Kuiper Express



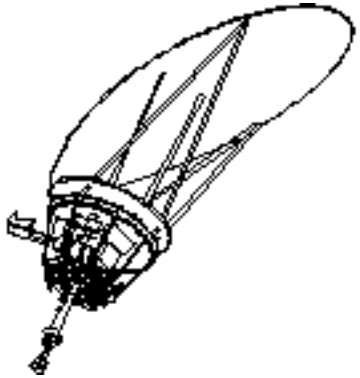
Europa Orbiter

X2000
First Delivery



Champollion

Mars Sample Return



Solar Probe

First Delivery

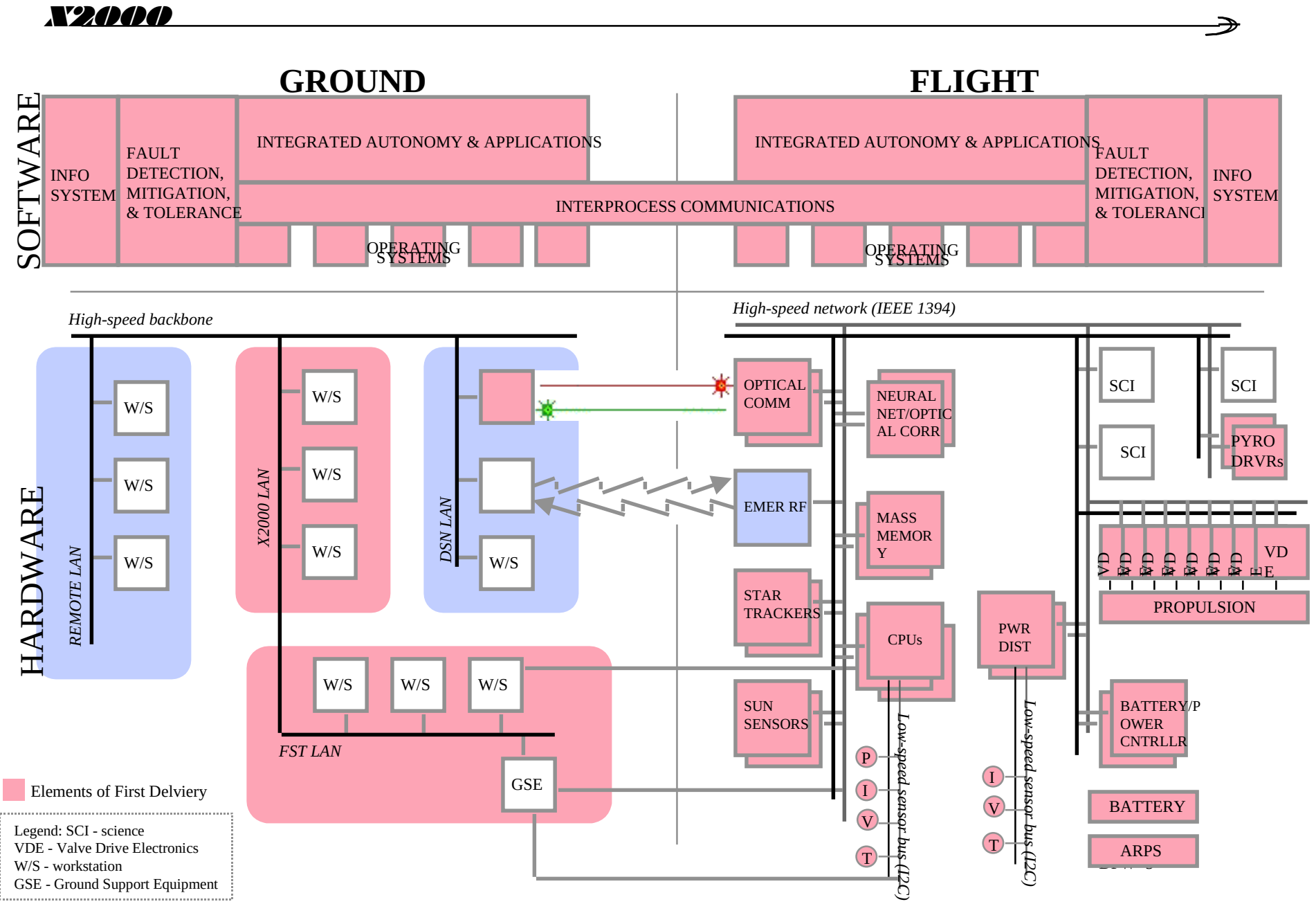
X2000

AN INTEGRATED and QUALIFIED engineering model FLIGHT and GROUND SYSTEM ARCHITECTURE, DESIGN, H/W & S/W; specifically:

- Flight System Micro-electronics
  - Computer, memory, & mass memory
    - Neural Network
    - Digital Signal Processor
  - Power & Pyro Switching
  - Sensor/Instrument I/O
  - Scaleable, modular, long life
  - RAD hardened designs, parts, & materials
  - Low Temperature, low power
  - Optical Comm
- F/S and GND S/W with W.S:
  - Operating systems
  - Generic auto NAV, 3-Axis A/C
  - Generic F/S-GND autonomy
  - Generic F/S-GND science data processing
  - Generic GND CMD/TLM processing/display
- ARPS power source
- Hydrazine microthrusters and variable propellant regulators
- Other: Additional micro-electronic components, structure, thermal, propulsion, etc. as budget allows

GND = Ground **W.S.** = Work Station **A/C** = Attitude Control **I/O** = Input/Output Interface
F/S = Flight System **S/W** = Software **CMD** = Command **TLM** = Telemetry **ARPS** = Advanced Radioisotope Power Source

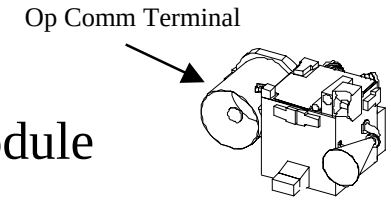
X2000 First Delivery Block Diagram



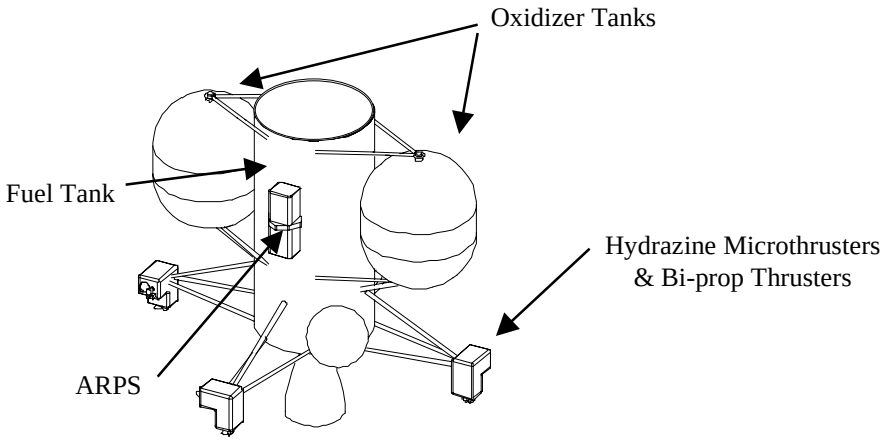
Europa Orbiter; SEP Configuration

X2000

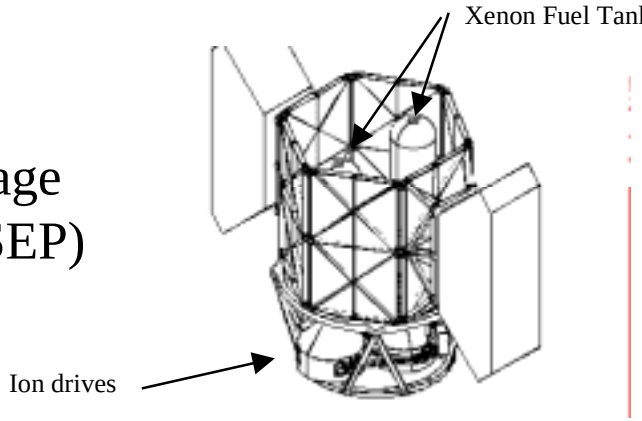
Equipment Module



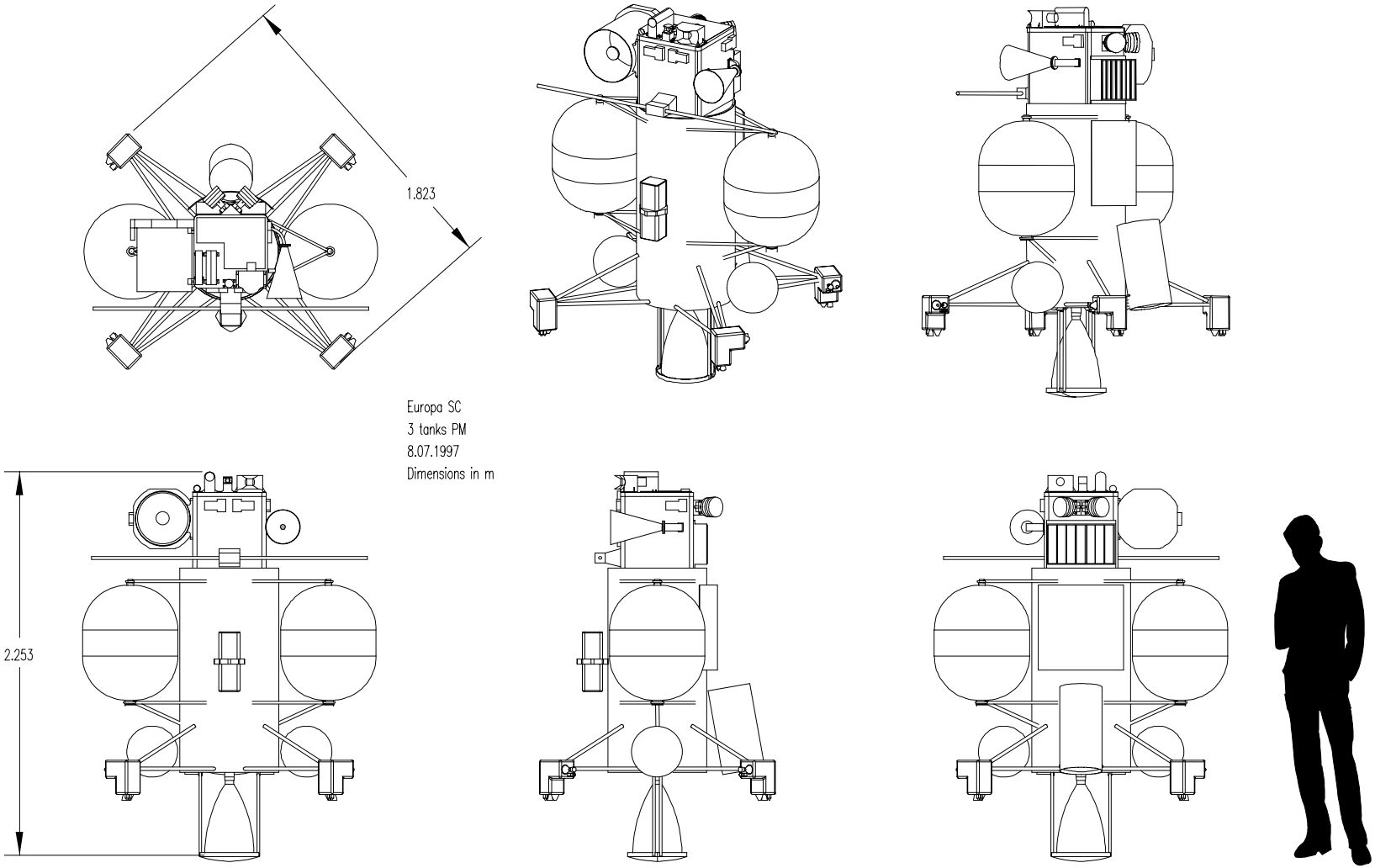
Propulsion Module



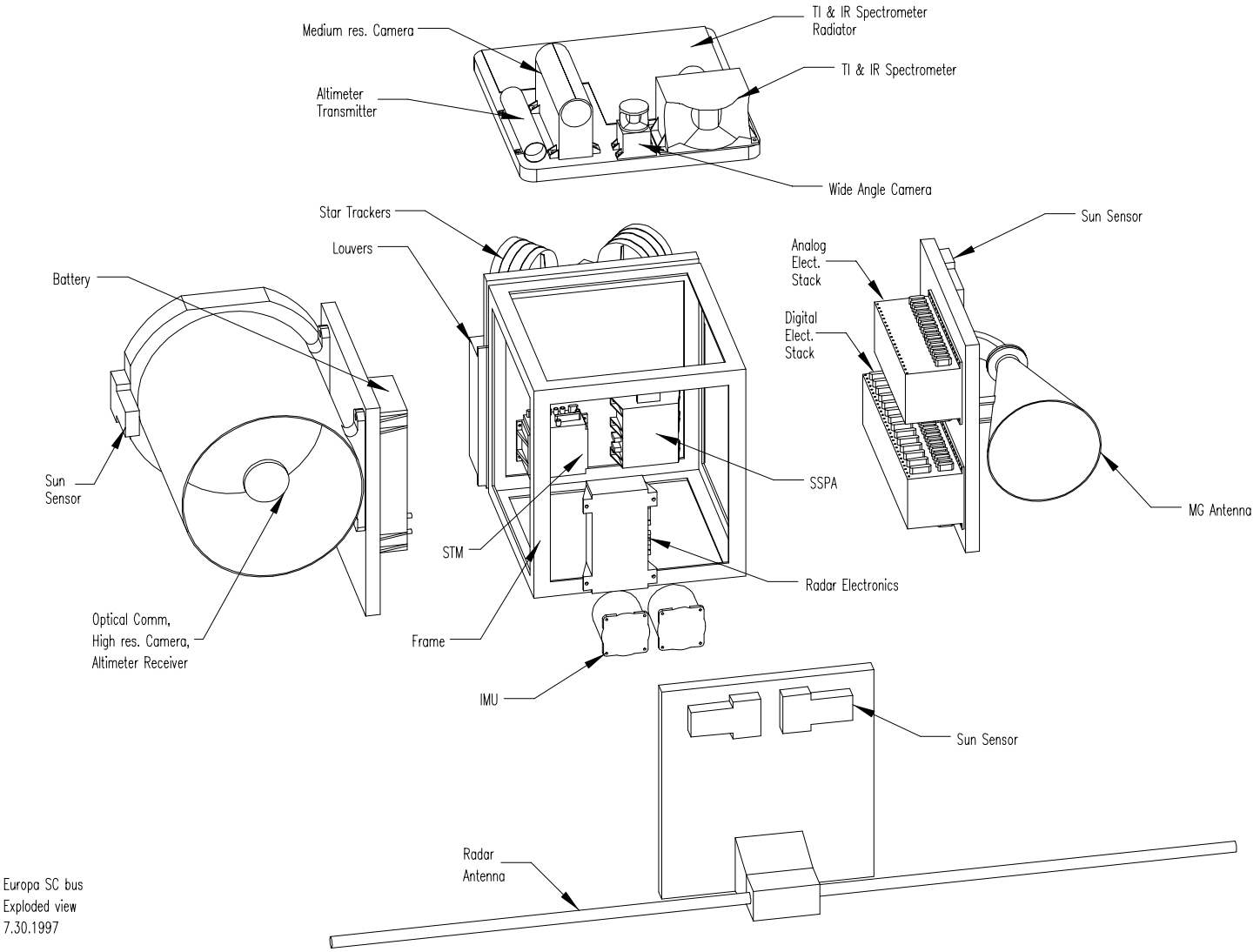
Interplanetary Injection Stage
(Solar Electric Propulsion-SEP)



Europa Orbiter Baseline Configuration



X2000 Bus with Ti Frame, Exploded View



X2000 Packaging Solutions: Modular Architecture Adapts to Multi-Spacecraft Missions

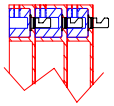
X2000

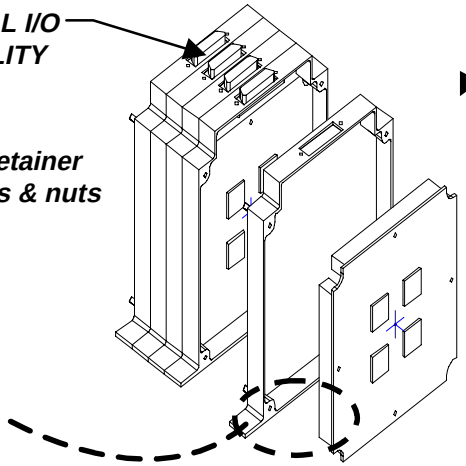
EXTERNAL I/O CAPABILITY

NEW SUPPORT FRAME provides system flexibility

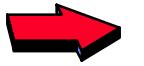
NEW Z-AXIS CONNECTOR versatile system integration & test

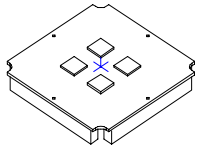
Guide Pin / Retainer eliminates bolts & nuts

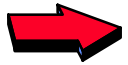




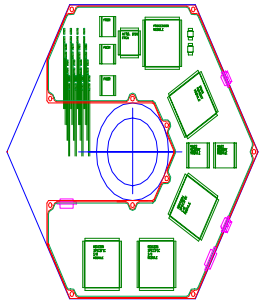
HMC ASSEMBLY



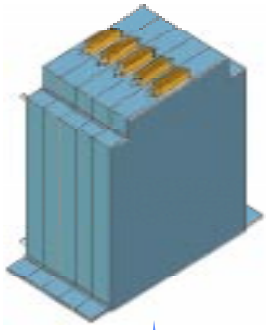




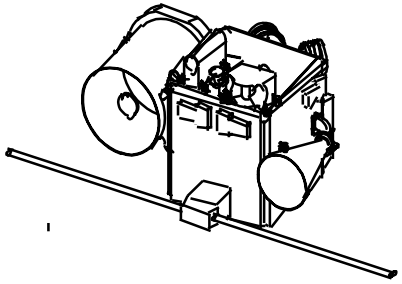
AVIONICS SLICE



CHAMPOLLION INTEGRATED SLICE

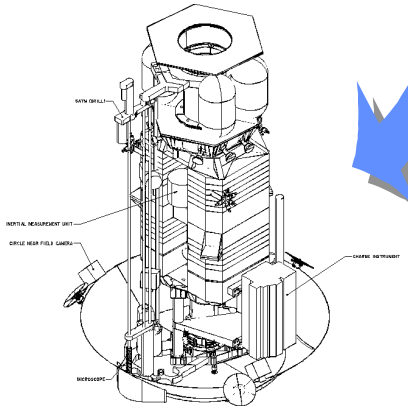


Europa Orbiter



HMC ADVANTAGES:

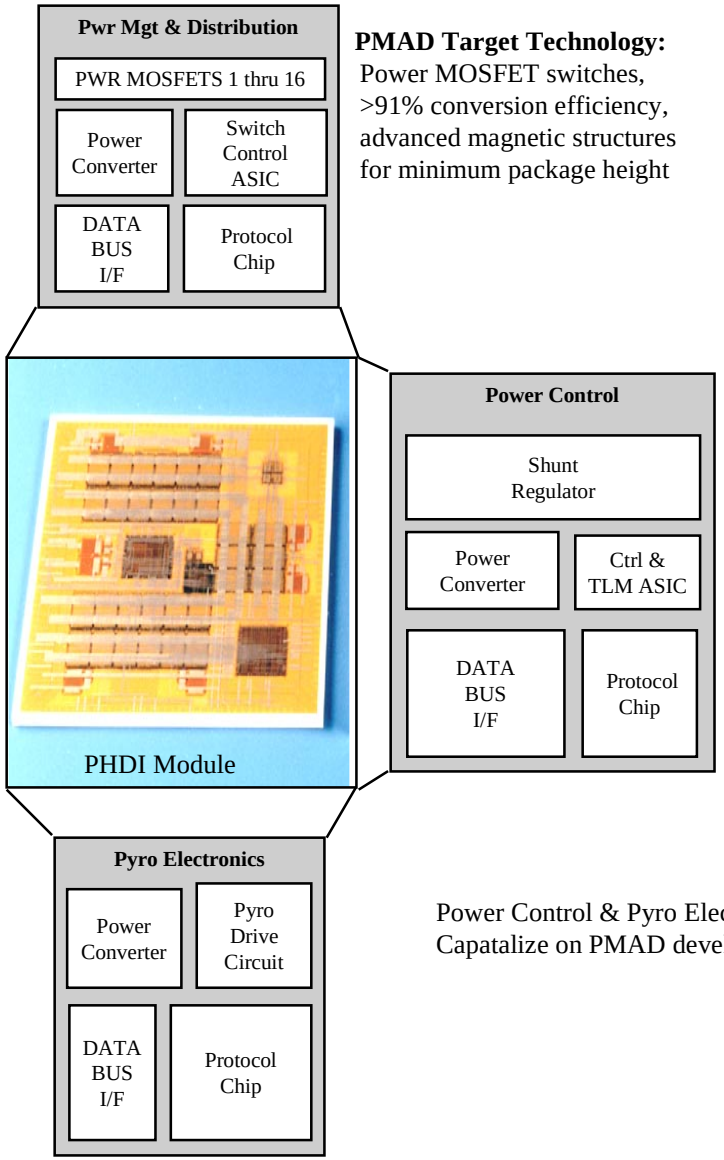
1. Common Modular Design for all subsystems
2. Designed for Manufactability
3. Designed for Test & Integration
4. Expandable
5. Provides improved thermal, dynamics, radiation and EMI/EMC design



Champollion Lander

Power Microelectronics Technologies

X2000



PMAD Target Technology:
Power MOSFET switches, >91% conversion efficiency, advanced magnetic structures for minimum package height

Power Control & Pyro Electronics
Capatalize on PMAD development

Overview

Current Technology: PC Board packaging, discrete component control circuit, relay enable and command switches and SCR fire circuit for pyros

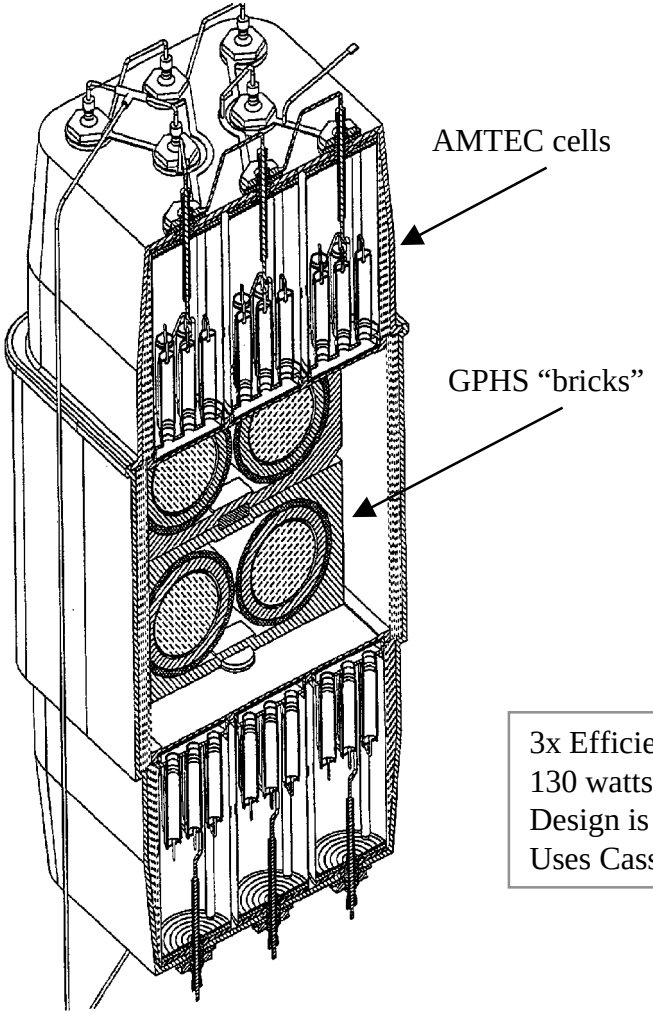
Target Technologies: 1. Mixed signal ASICs, 2. Power High Density Interconnect (PHDI) packaging, 3. modular fault tolerant design

Benefits: 1. Reduce mass and volume, 2. standard command interface**,** 3. Provides peak power at maximum load, 4. configurable to various power source characteristics

Impact of Fallback: Several kg mass increase, increase in volume

Key Issues: Laser vs. NSI Pyro technology, thermal design, fault tolerant control circuit

Advanced Radioisotope Power Source (ARPS) Technology



Overview

Current Technology: *Galileo/Cassini* heritage RTG with 6-7% efficiency unicouple conversion

Target Technology: >20% conversion using either AMTEC

Benefits: Mass reduction, smaller quantity of radioisotope

Key Issues:lifetime; efficiency; radiator size; heat rejection temperature

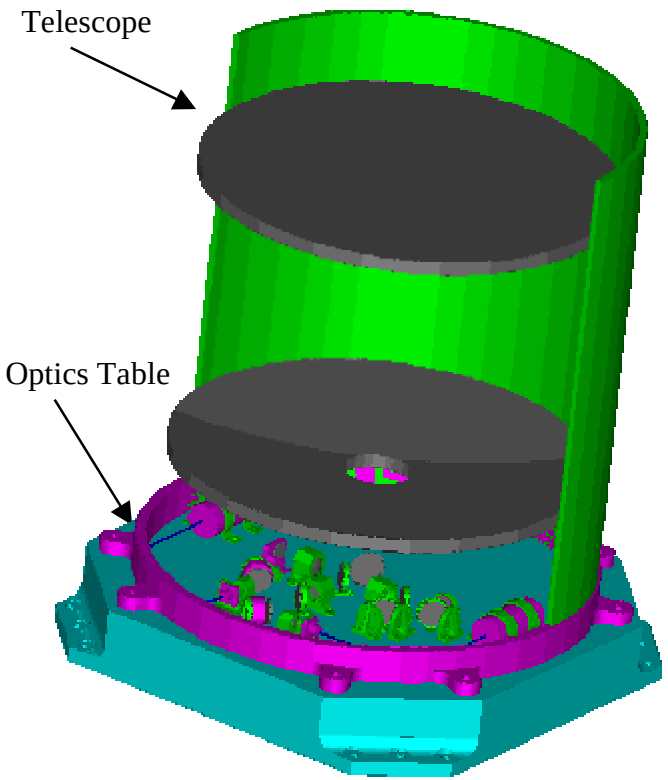
Impact of Fallback: > 12 kg mass increase

3x Efficiency over RTG's
130 watts after 15 yrs
Design is scaleable in 50W Units
Uses Cassini GPHS

GPHS = General Purpose Heat Source **RTG** = Radioisotope Thermoelectric Generator

AMTEC= A thermally regenerative electro--chemical device converting heat to electricity directly using a solid electrolyte. It is sealed and has no moving parts. Advanced Modular Power Systems (AMPS) is a small business licensed to develop these devices commercially.

Optical Communications Technology



Overview

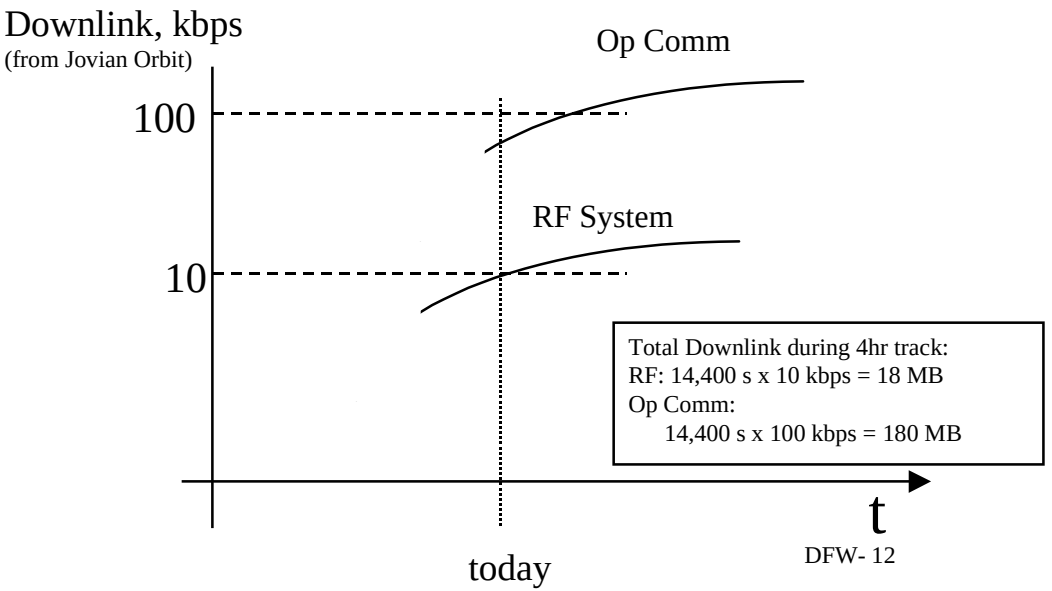
Current Technology: X/Ka-band RF telecommunications systems

Target Technology: 30-cm optical comm terminal, uplink & downlink

Benefits: Dramatic increase in telemetry rate at mass and power levels equivalent to RF telecom system; see plot below

Key Issues:lifetime, system-level fault protection

Impact of Fallback: Reduction in science data returned



Technology Comparisons

X2000

MPF Technologies

- RF telecom (basically a buy)
- Attitude & Information Management S/S
- RAD6000 (LMFS absorbs $2.5M)
- Software/Autonomy
  - object-oriented FSW
  - Well-used COTS Tools
- Benign rad environment (200 rad)
- Some partners
- Select engineering processes
- Hydrazine RCS system
- Entry, Descent, & Landing (EDL)
  - critical sequence
  - airbags
  - rad rockets
  - aeroshell
- Reliability: class C, short mission
- Relied on heritage for many parts & materials
- Basically two instruments
- Bare-bones functionality, capability-driven, one customer
- Solar powered design
- Standard voltages
- MPF EM $ ~ 104M

1st delivery technologies

- Optical Comm
- AIM+ + AIM + PPS + Optical Correlator/Neural Net)
- PowerPC
- Software/Autonomy
  - object oriented
  - unified flight ground architecture
  - next generation autonomy
  - COTS Tools
- Rad hard parts & materials program (Mega-rads)
- A partnering hoedown
- Develop new processes
- Propulsion Technologies: bi-propellant, hydrazine microthrusters, etc
- No EDL
  - orbit injection sequences are critical
- Reliability: long-life, dual string
- Almost entirely new development
- Several instruments
- Science driven requirements, many technology enhancements, many customers
- Radioactive power supply (+ DOE interface)
- Push to low voltages
- 1st delivery budget ~ $86M